Variational data analysis for generating ocean climatologies (Diva) and web-based distribution of data products (OceanBrowser)

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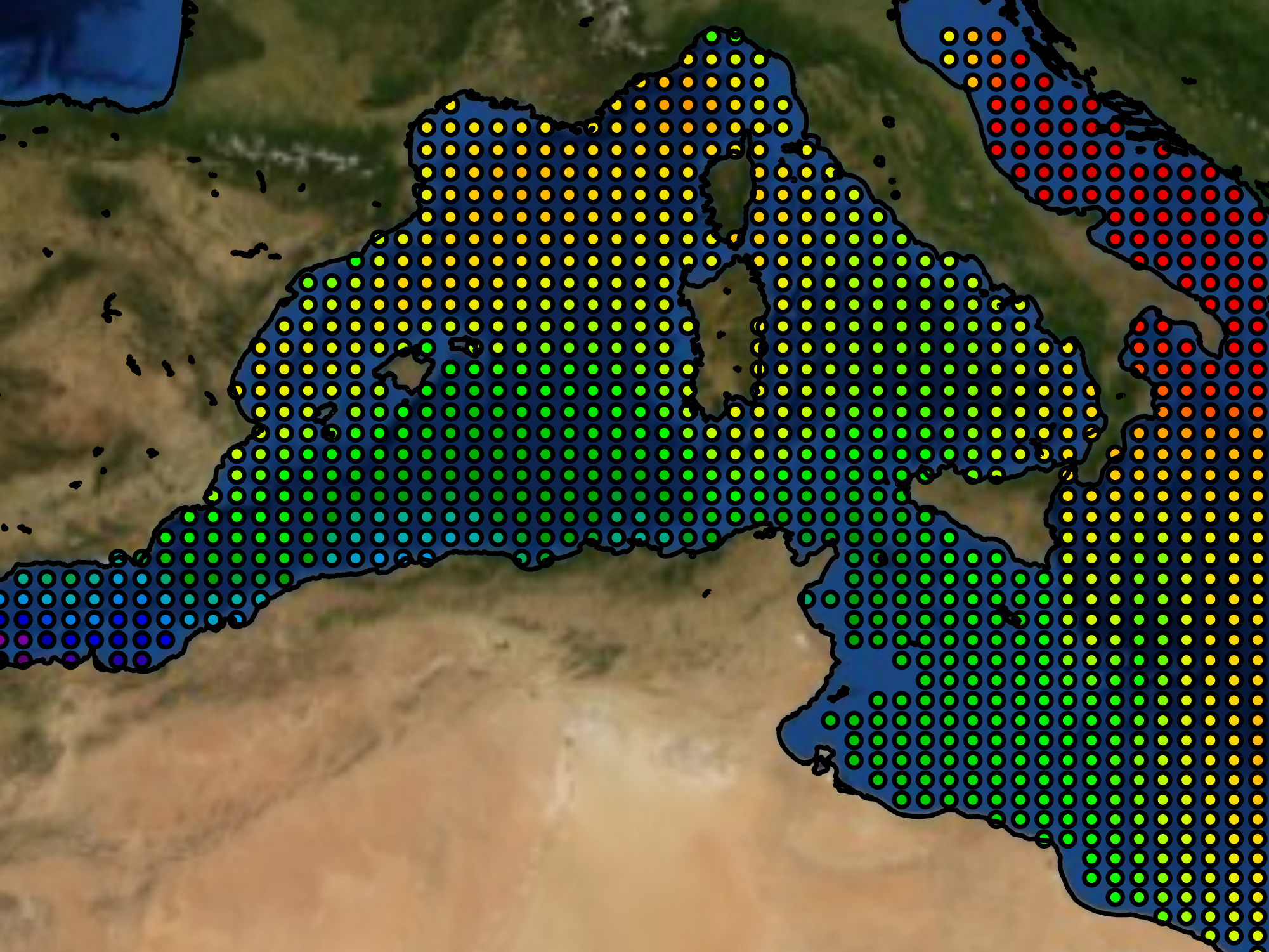
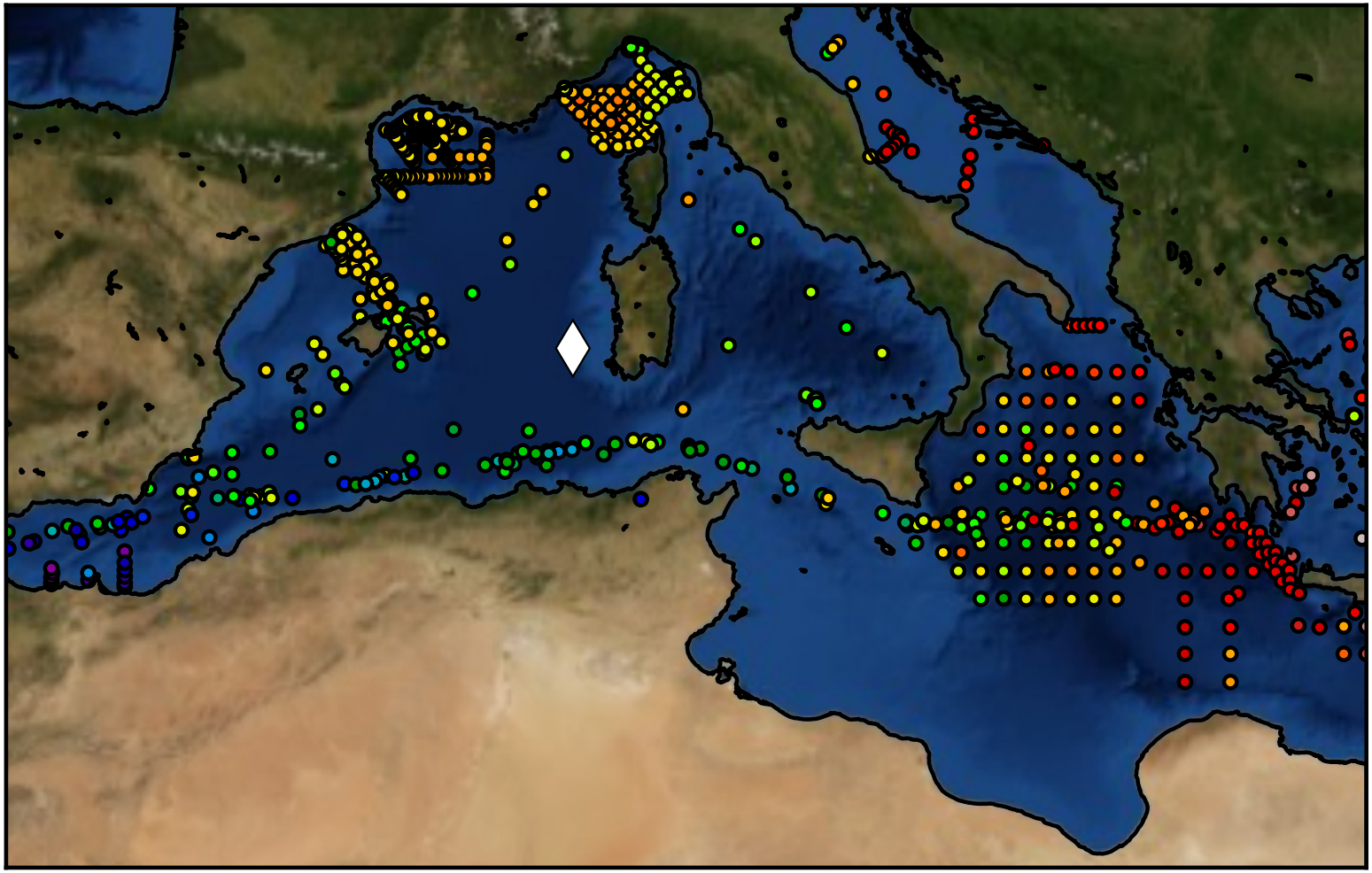
Acknowledgement: SeaDataNet,
EMODnet Chemistry, EMODnet Biology



Objectives of data analysis



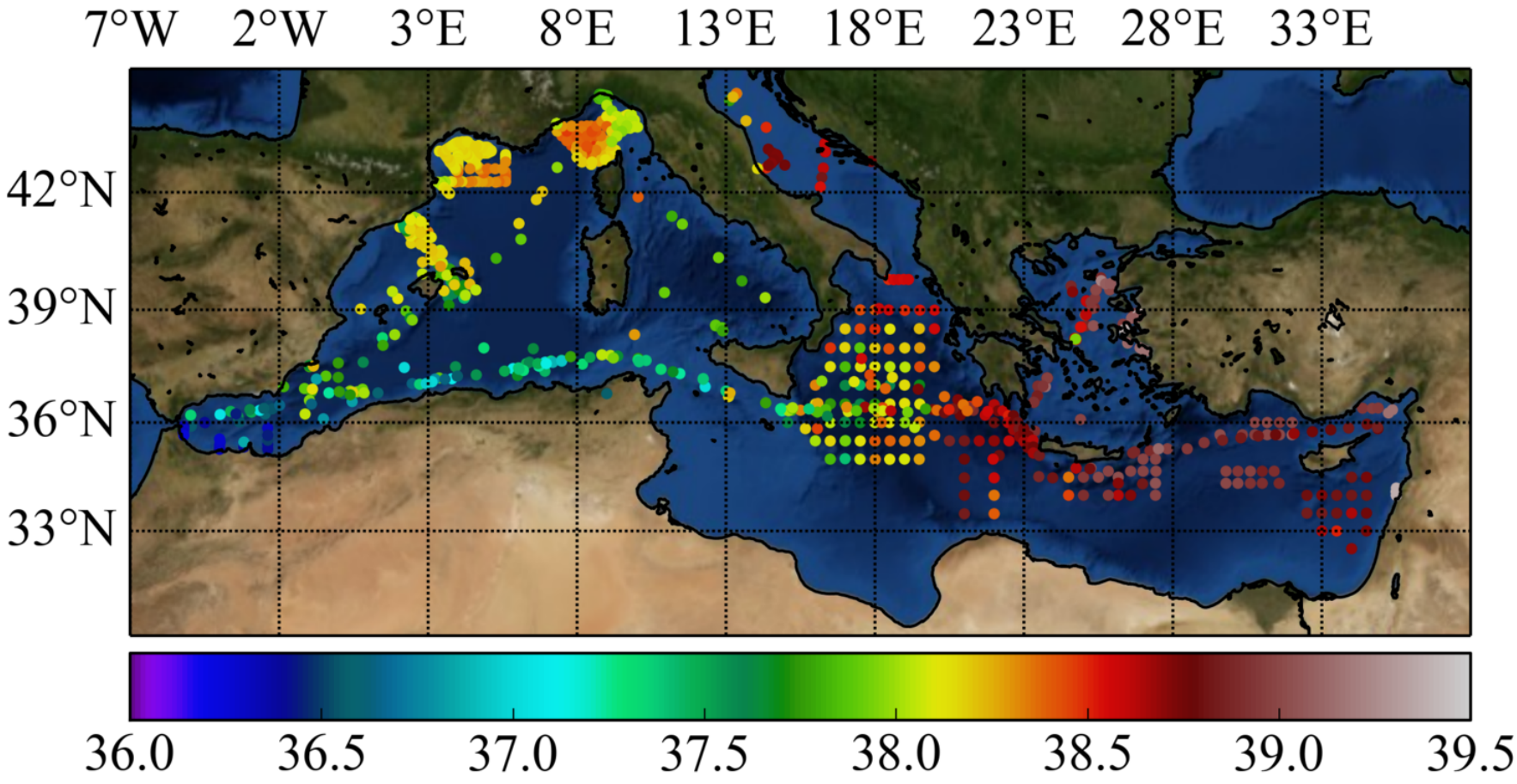
1. Temperature at the $\diamond$?
2. Mean field?
3. Uncertainty of your estimate for 1 and 2?

Variational analysis

What is the "*best looking*" field close to the observations?

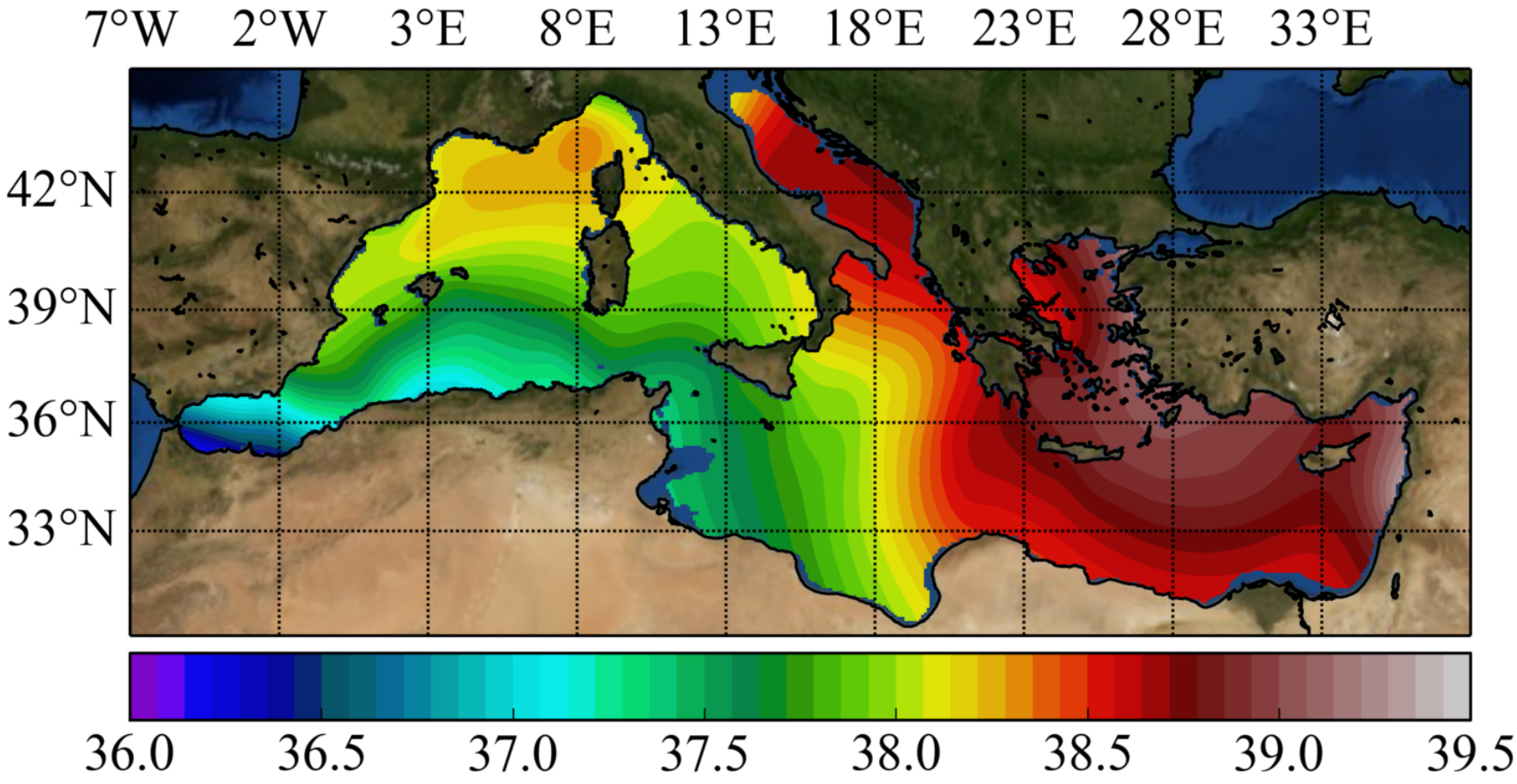
How can we quantify "*good-looking*"?

Good-looking?



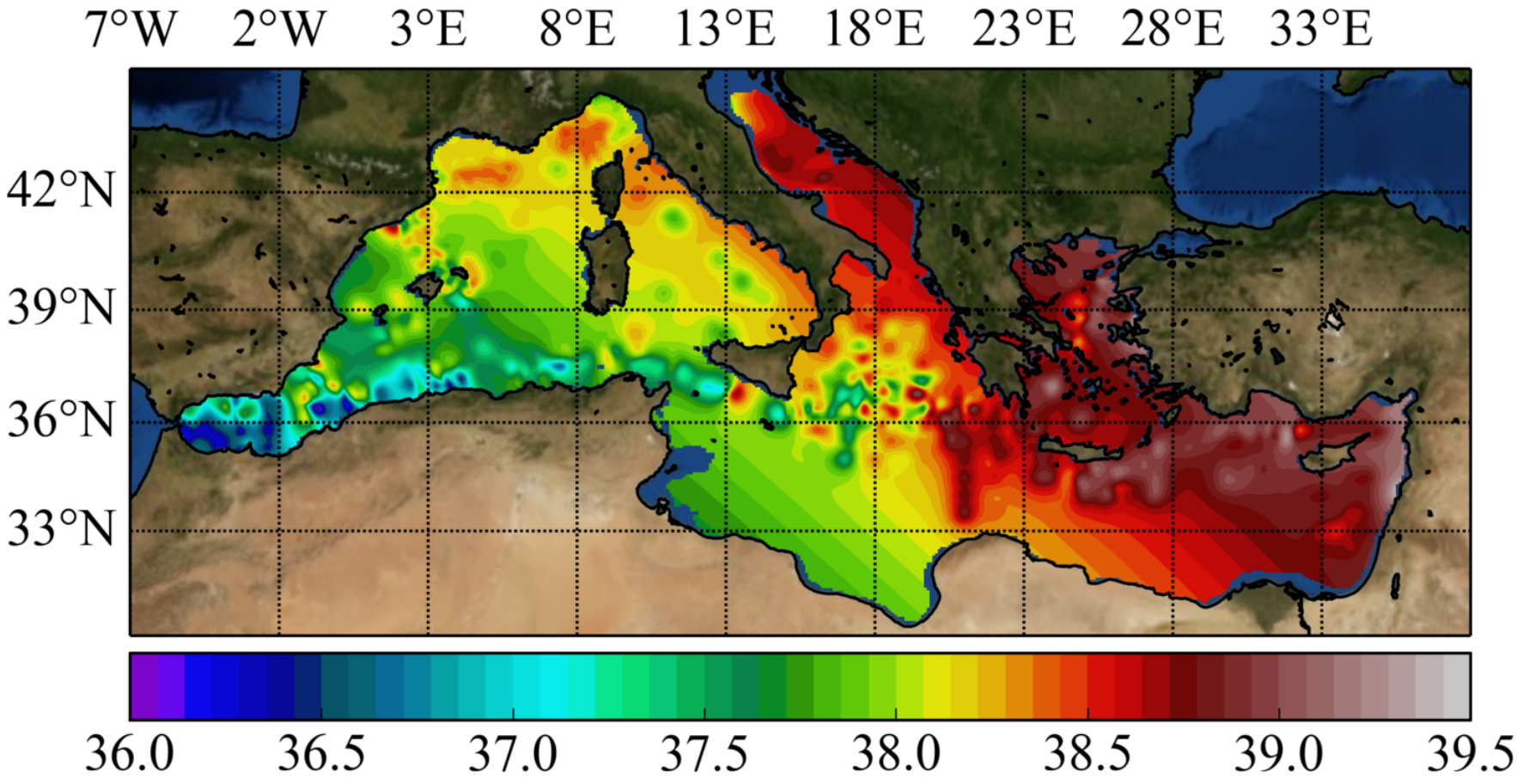
Salinity in the Mediterranean Sea

Good-looking?



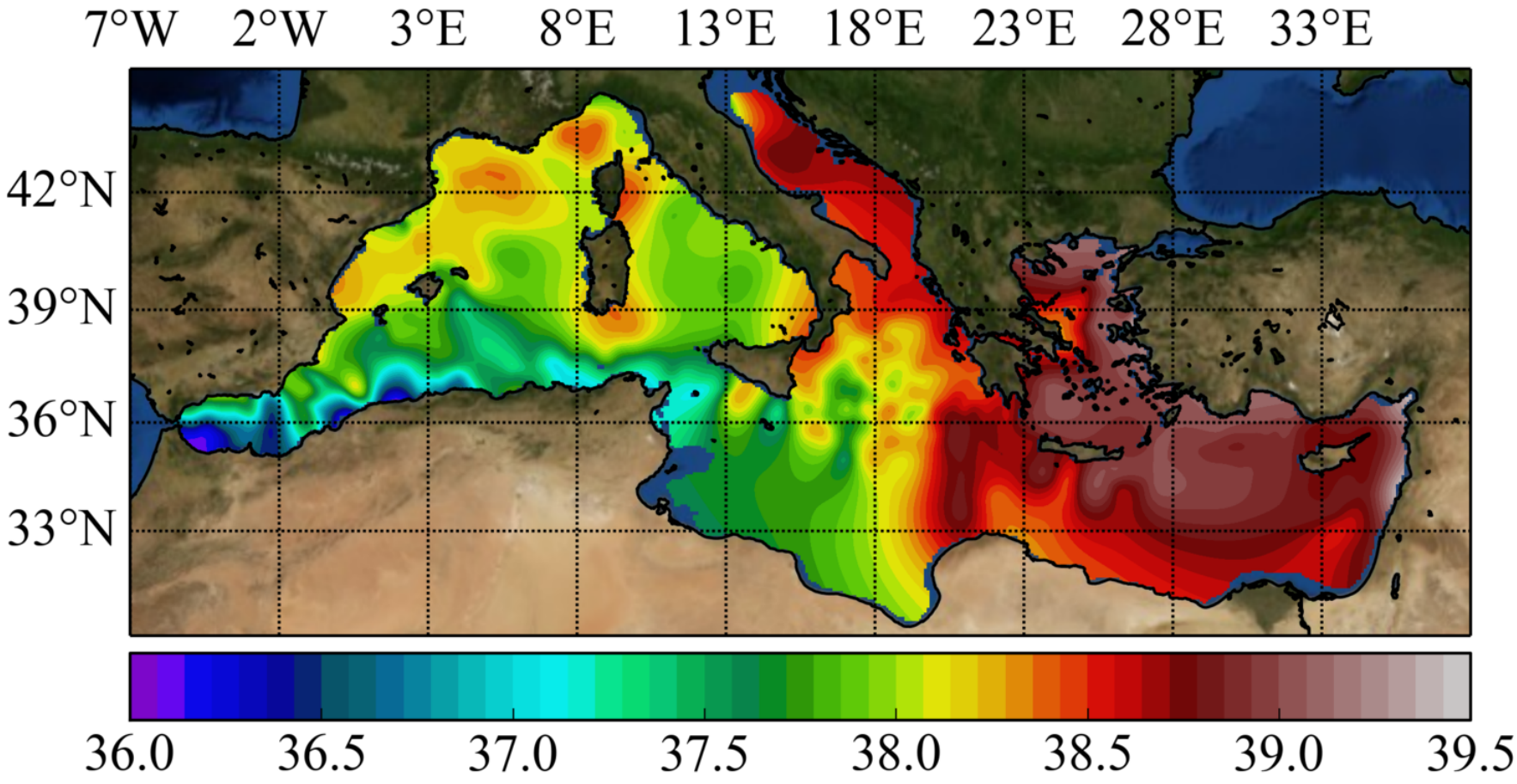
Too smooth!

Good-looking?



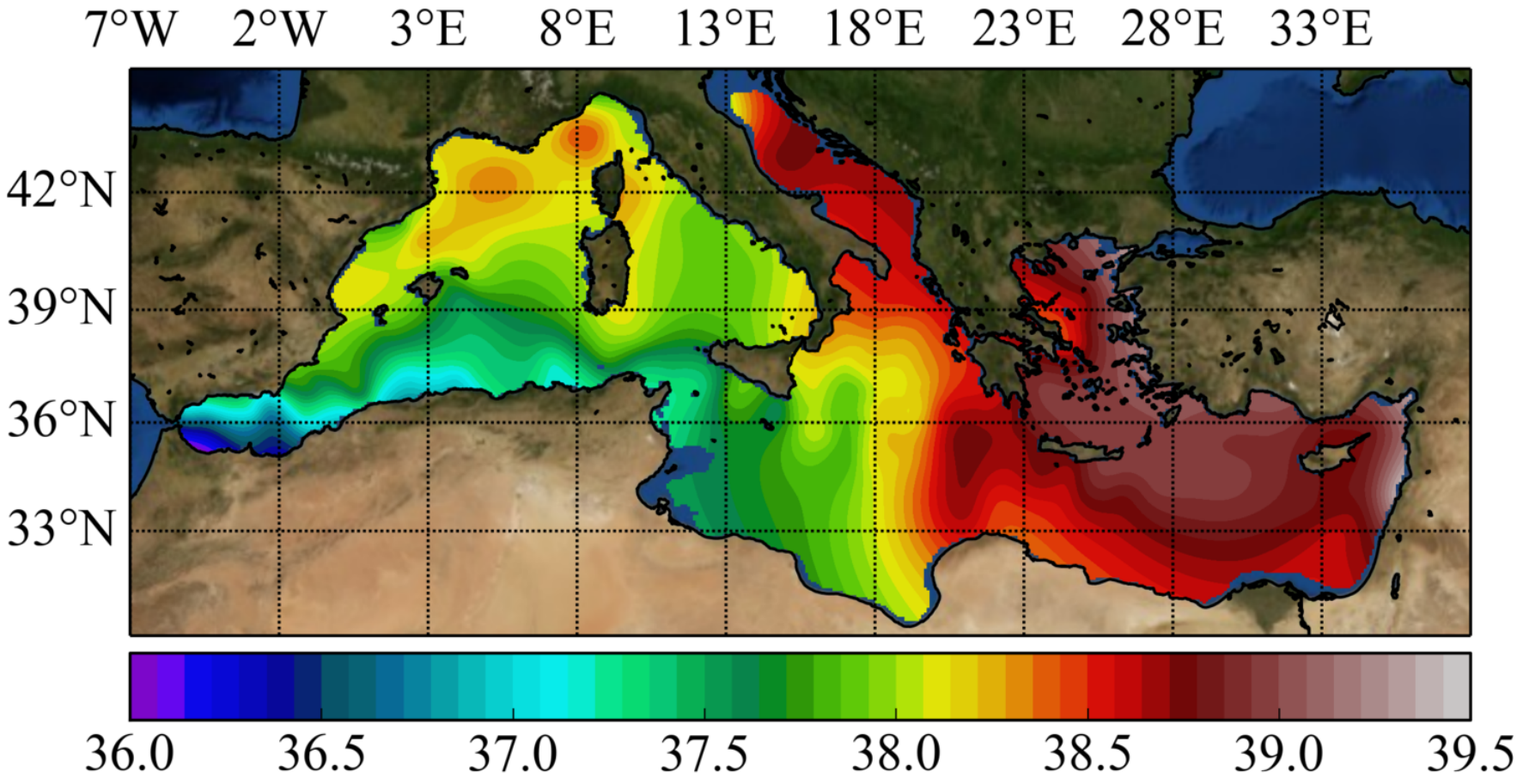
Too noisy!

Good-looking?



Slightly better. . .

Good-looking?



OK, looks nice!

Good-looking analysed field?

Close to observations but... not too close

cruises should not be visible

Smooth variations but... not too smooth

more than a uniform gradient should be visible

Good-looking analysed field?

Analysis parameters:

1. correlation length scale
2. signal-to-noise ratio

determined from data themselves

Diva Cocktail Recipe

Ingredients:

- 1 1/2 oz vodka
- 1/2 oz passion-fruit juice
- 1/2 oz lime juice
- 1 tbsp cherry juice
- fill with soda

Diva Cocktail Recipe

Ingredients:

- Smoothness
- Observation constraint
- Behaviour constraint

Diva Cocktail Recipe

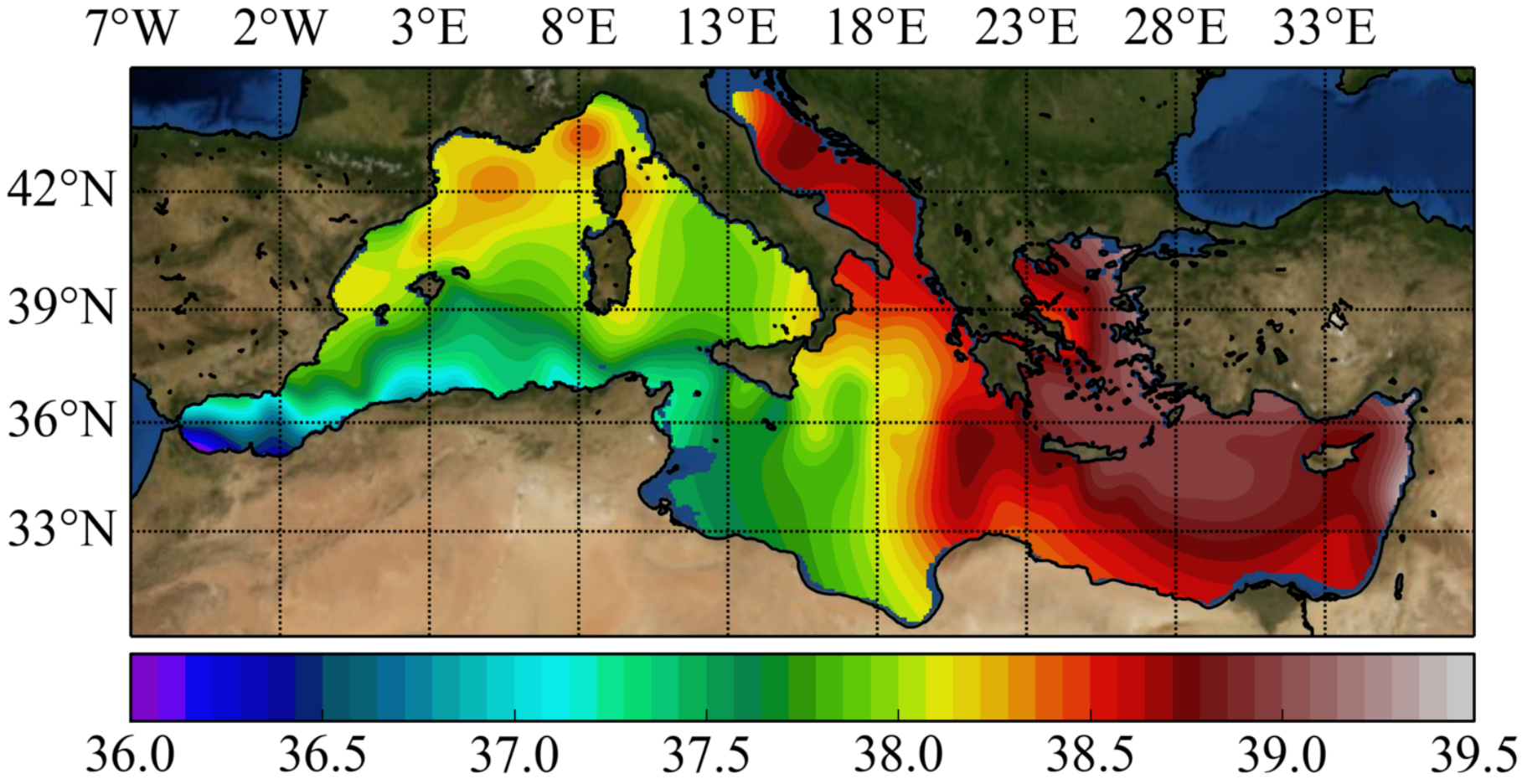
Proportions:

- correlation length scale
- signal-to-noise ratio

Diva **2D**: longitude/latitude

Procedure repeated

- for various depth levels
- for different periods



Diva in **3D**

- Result layers *stacked* together

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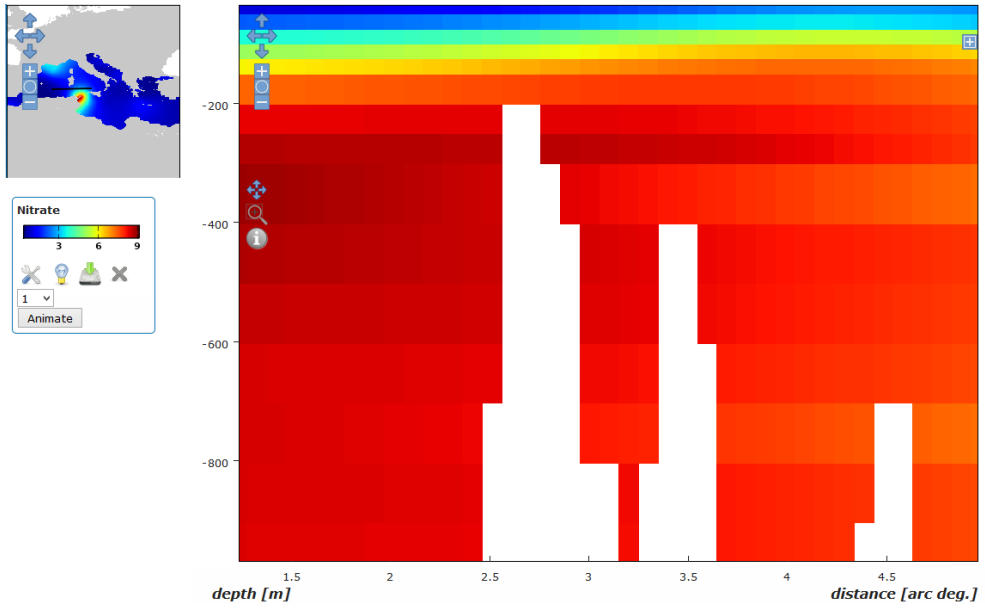
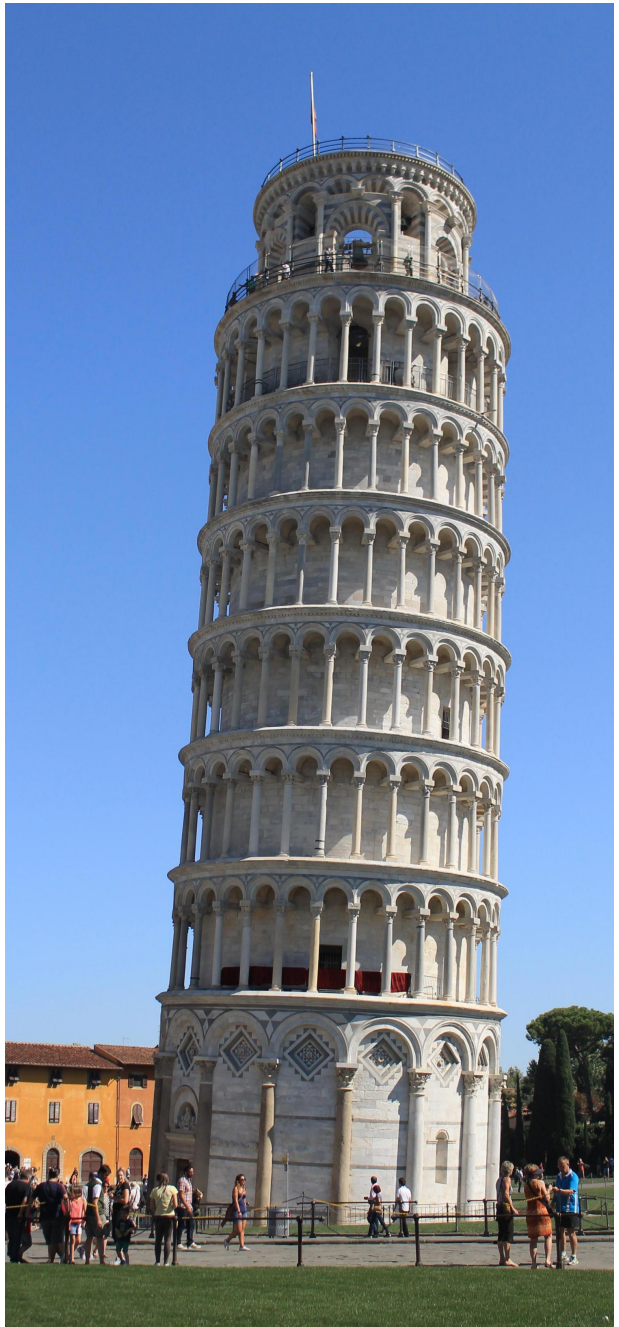


Diva in **3D**

- Result layers *stacked* together
- Problems may occur between two levels. . .
- . . . so stabilisation is required



Extension to higher dimensions

Classic Diva: smoothness constraint only in 2D
DIVAnd: arbitrary high dimensional space (time, depth, . . .)

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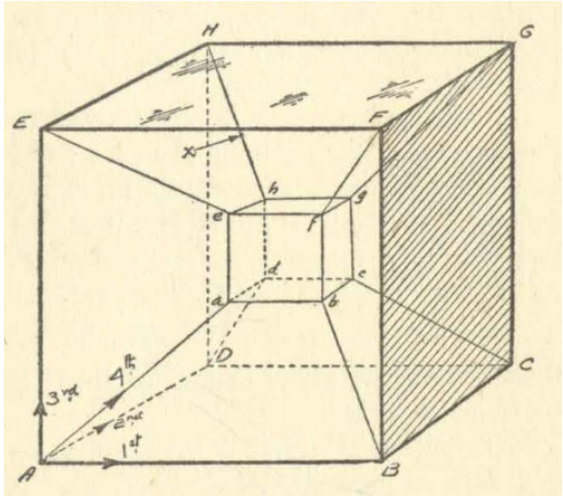

FIG. 19.—The Tesseract.

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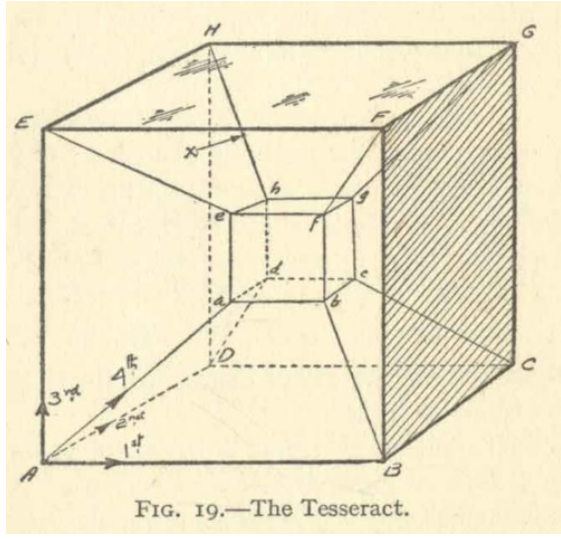


FIG. 19.—The Tesseract.

2013: [*Theory of Diva in the Fourth Dimension (and more)*, Alexander Barth]

$$K^{n,m}(\vec{x}) = \frac{2}{\Gamma(\nu)} \left(\frac{|\mathbf{L}^{-1}\vec{x}|}{2} \right)^{\nu} \mathrm{K}_{\nu}(|\mathbf{L}^{-1}\vec{x}|)$$
$$+ \quad \text{many more!}$$

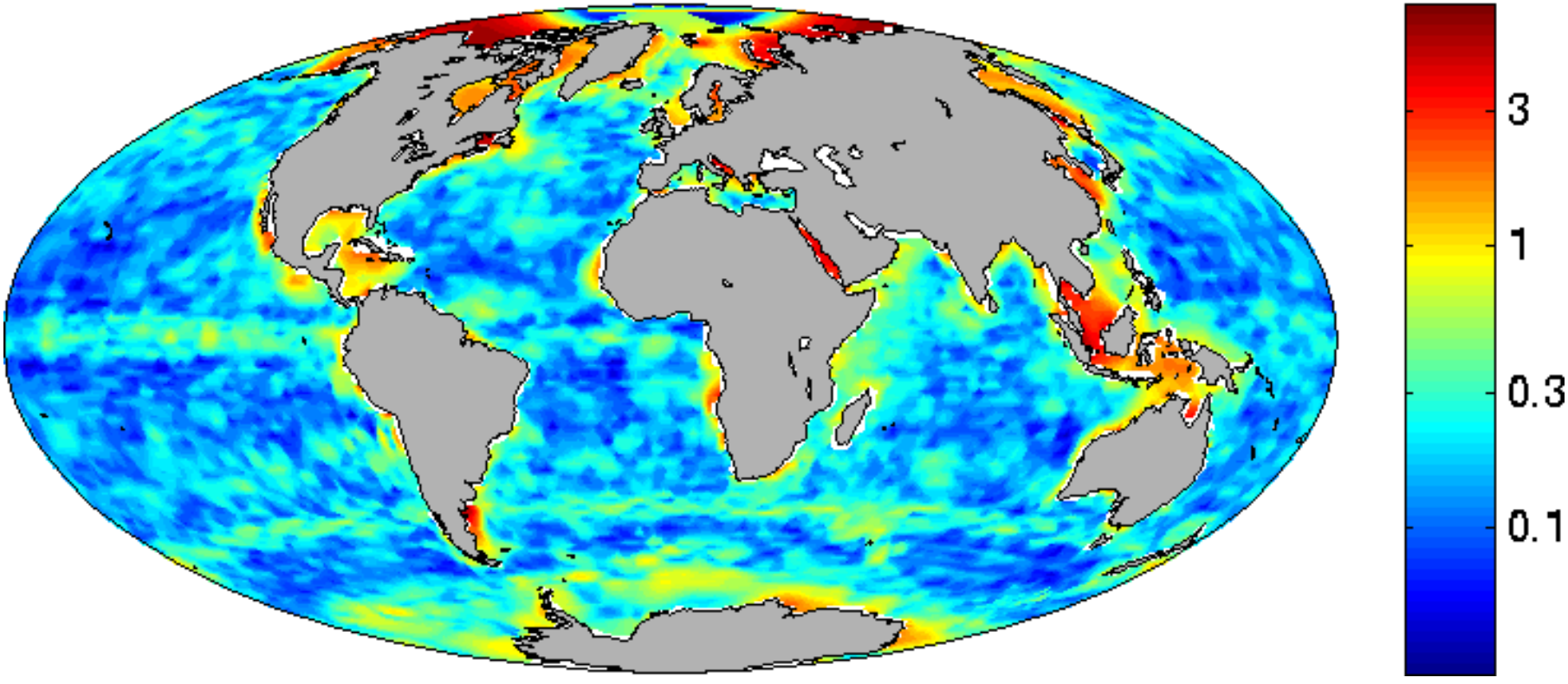
Application

- Pseudo-observations: temperature from a global ocean model (NEMO-LIM2).
- Horizontal resolution: $\approx 2^\circ$
- Positions: ARGO observations from 2007
- Analysis quality: comparison between
  - analysed field
  - original model data
- Observations: daily model results
  Analysis: monthly means
- Surface fields only

Application

Analysis parameters: optimized by minimizing RMS to model climatology

RMS 3D-analysis

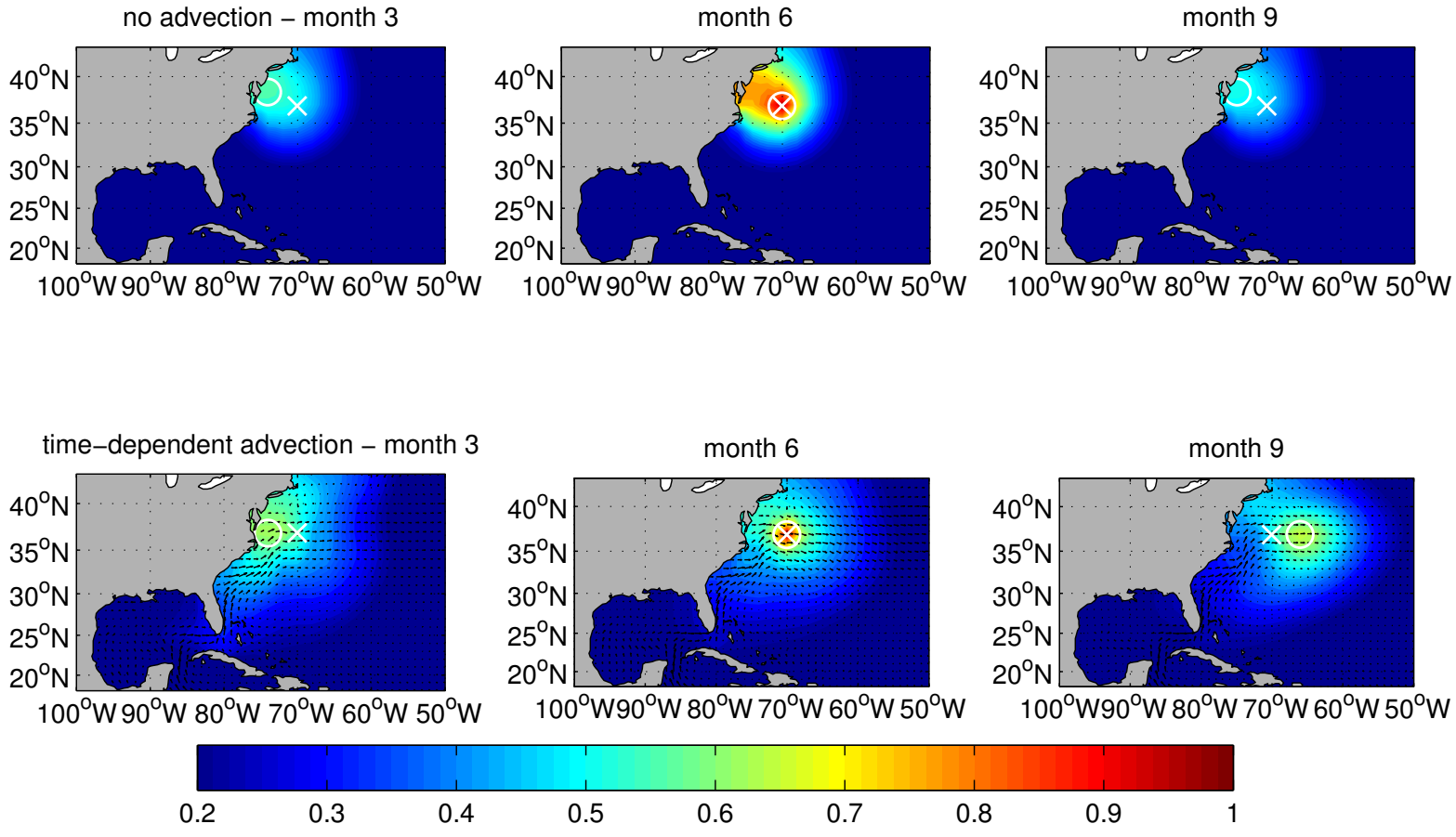


Advection constraint

Forces gradients of interpolated fields to align with currents

In 3D: distinction between upstream and downstream

3D case: background error covariance without (upper row) and with advection constraint (lower row) for a data point located at the cross and at month 6



Comparison

Experiments:

- with/without time dimension
- with/without advection

Skill-score (in %): relative reduction of mean square error

dimension of analysis	advection constraint	skill-score
2D	no	0

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2D	yes	29
3D	no	27

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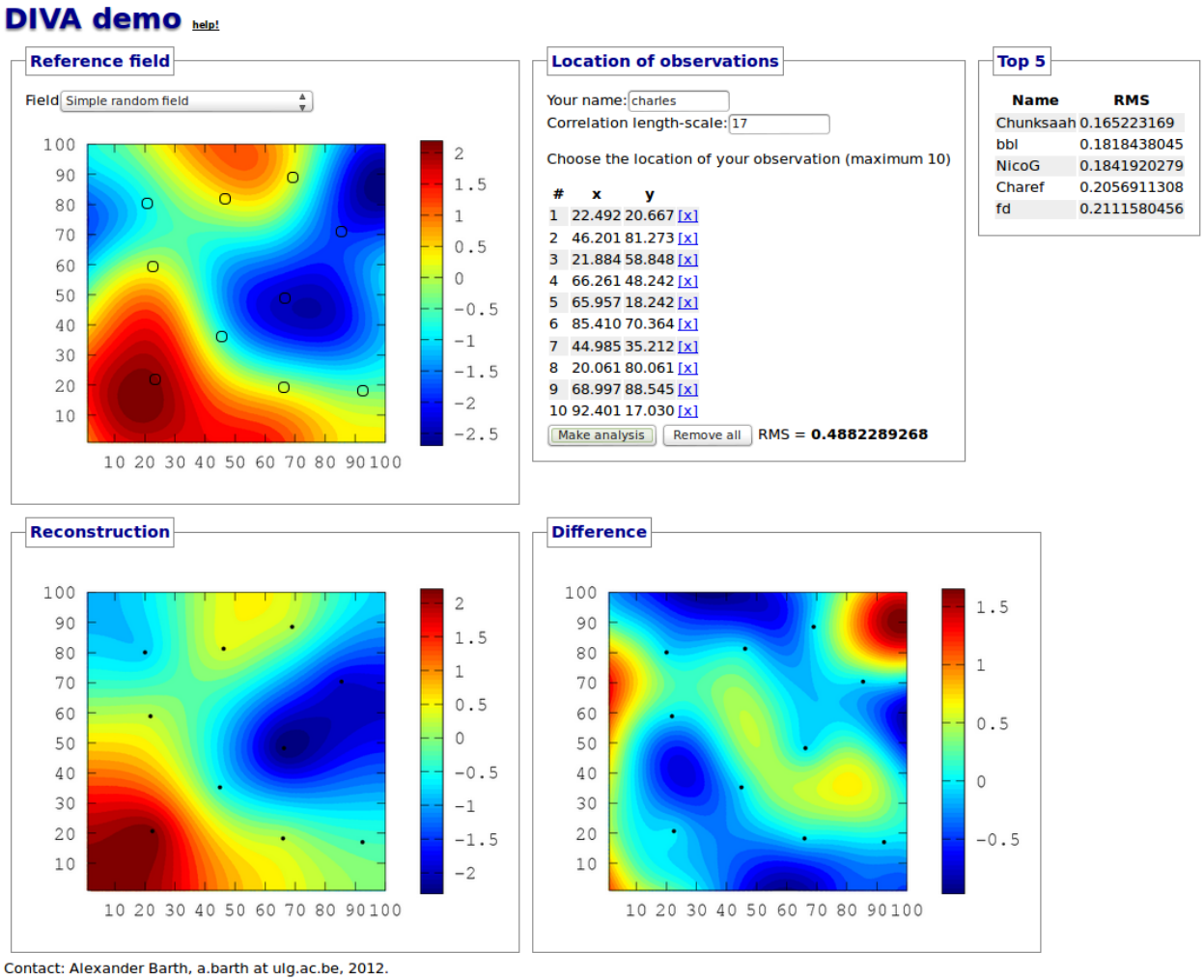
2D	no	0
2D	yes	29
3D	no	27
3D	yes	44

Want to use Diva?

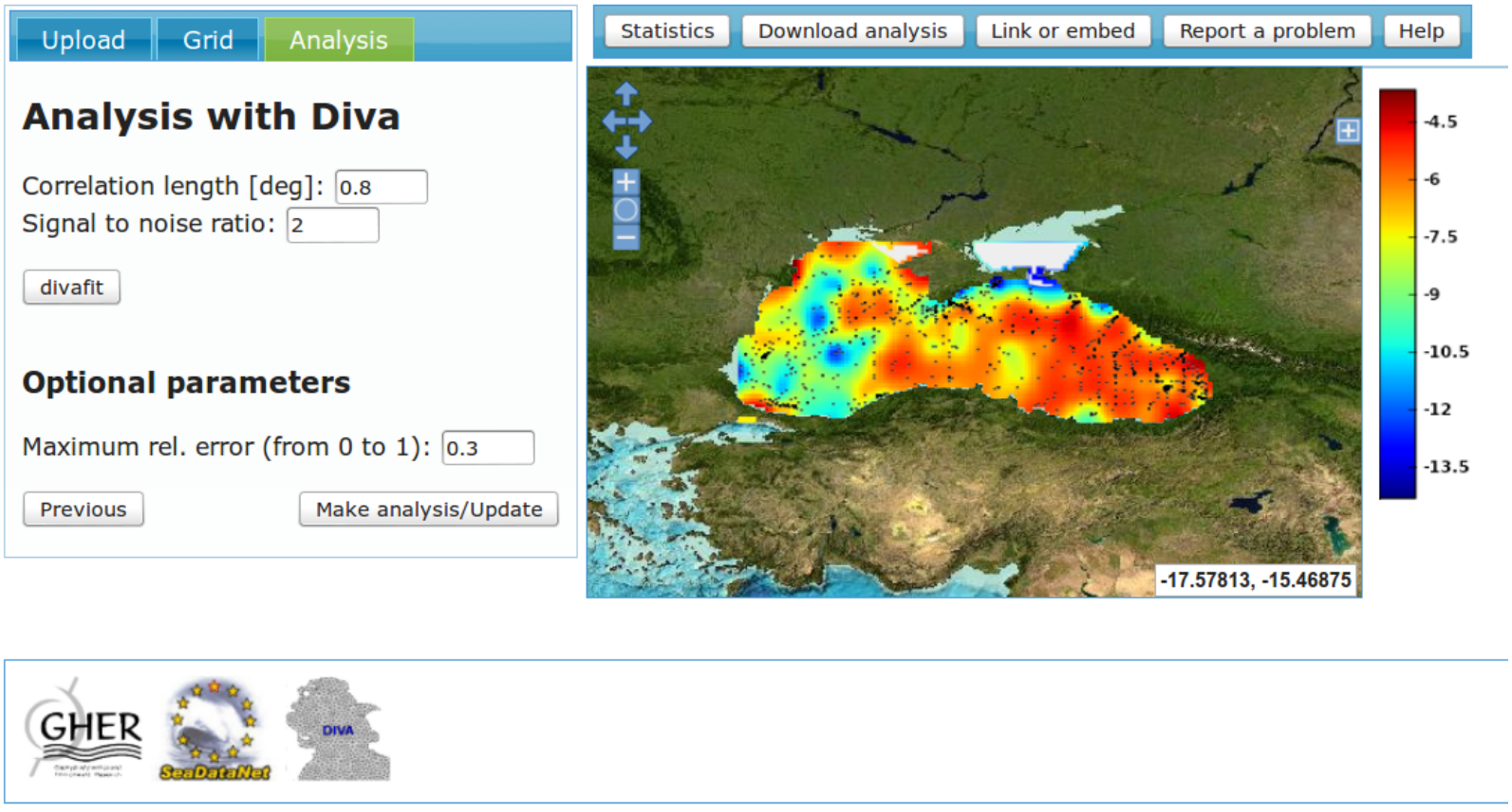
Playing. . .



http://data-assimilation.net/Tools/divand_demo/html/

Want to use Diva?

With your own data. . .

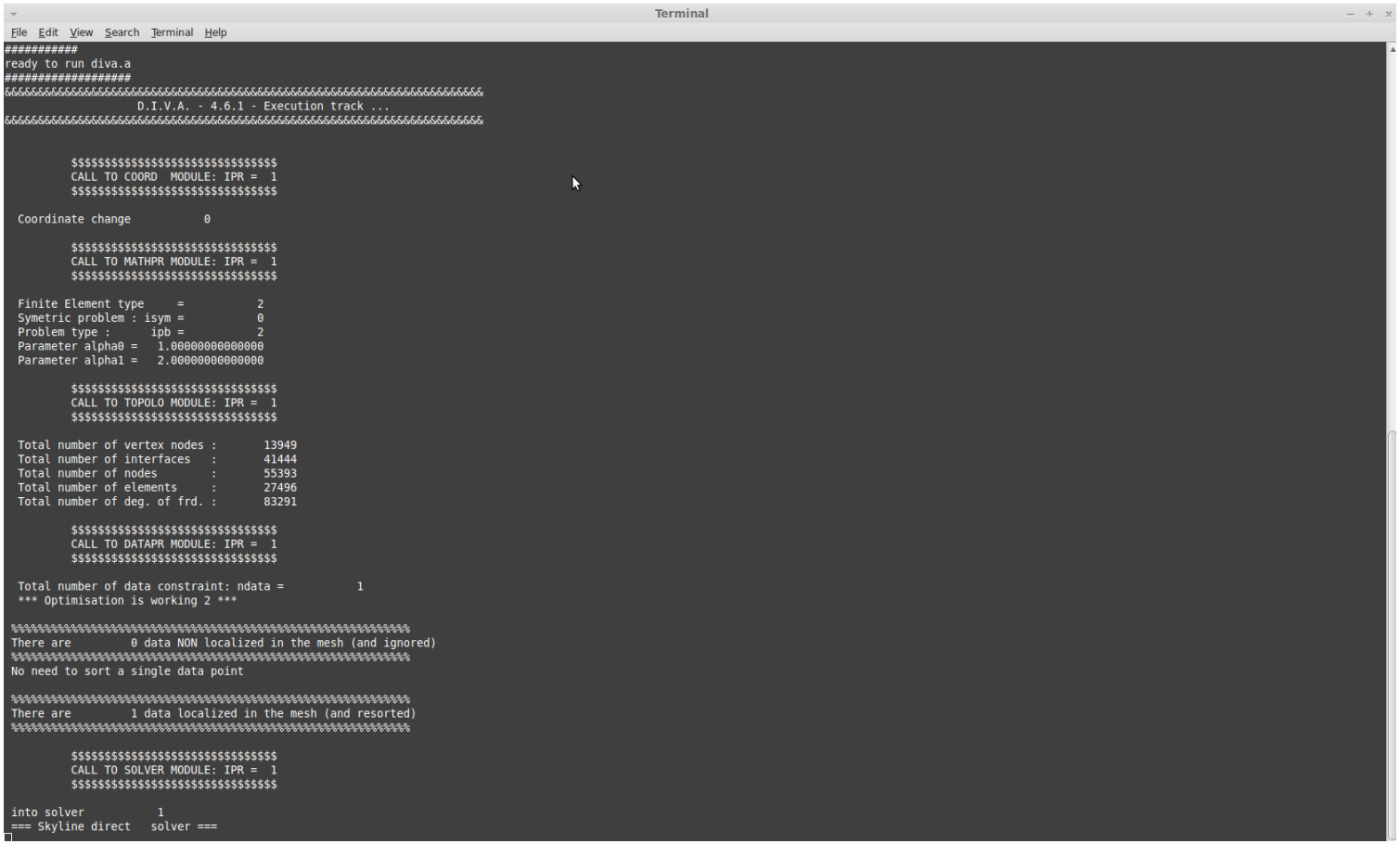


http://gher-diva.phys.ulg.ac.be/web-vis/diva.html or ODV

Want to use Diva?

For serious work:

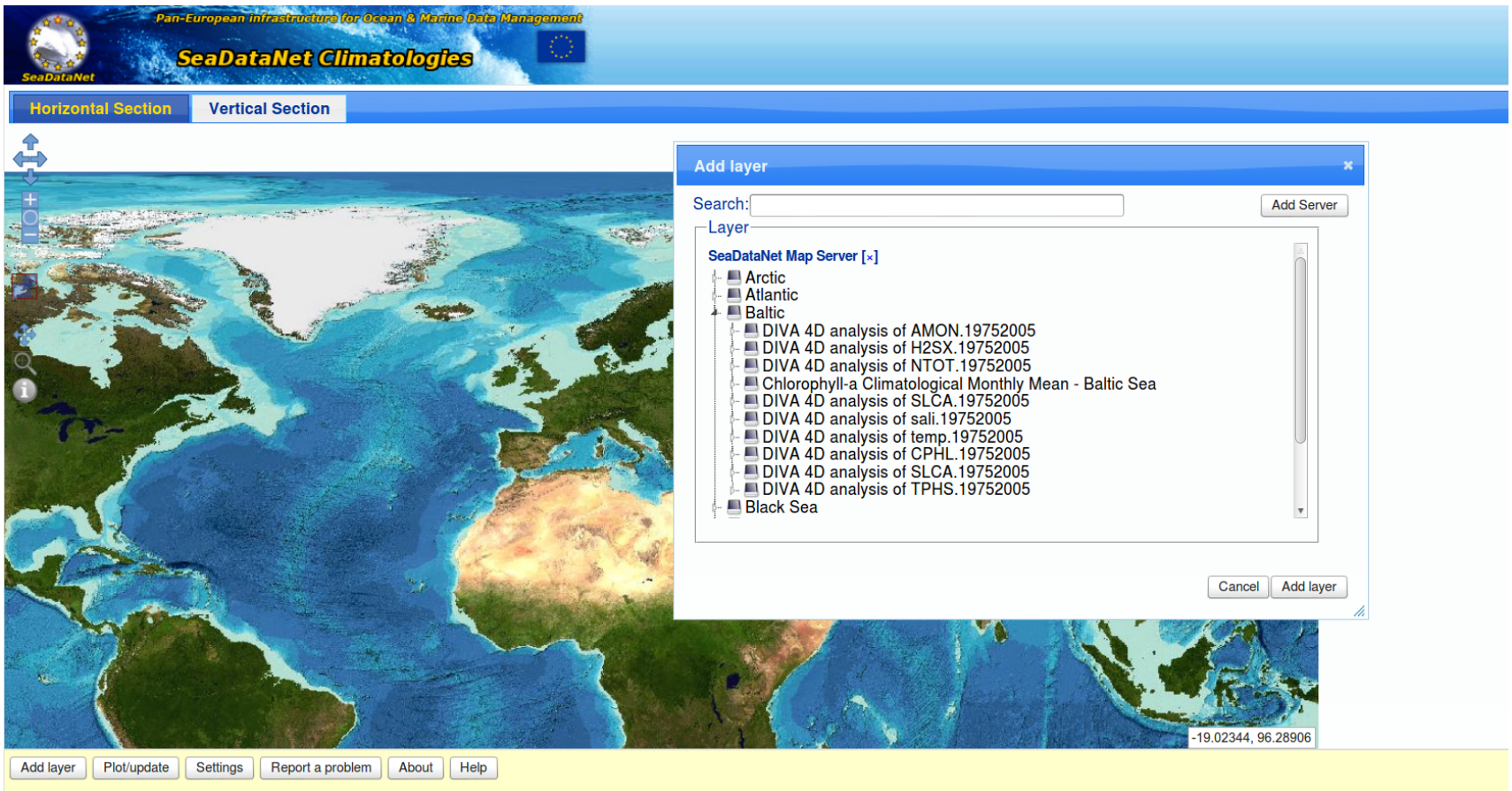
- 2D version (for production), open source, GPL
- nD version (for research), open source, GPL



http://modb.oce.ulg.ac.be/mediawiki/index.php/DIVA

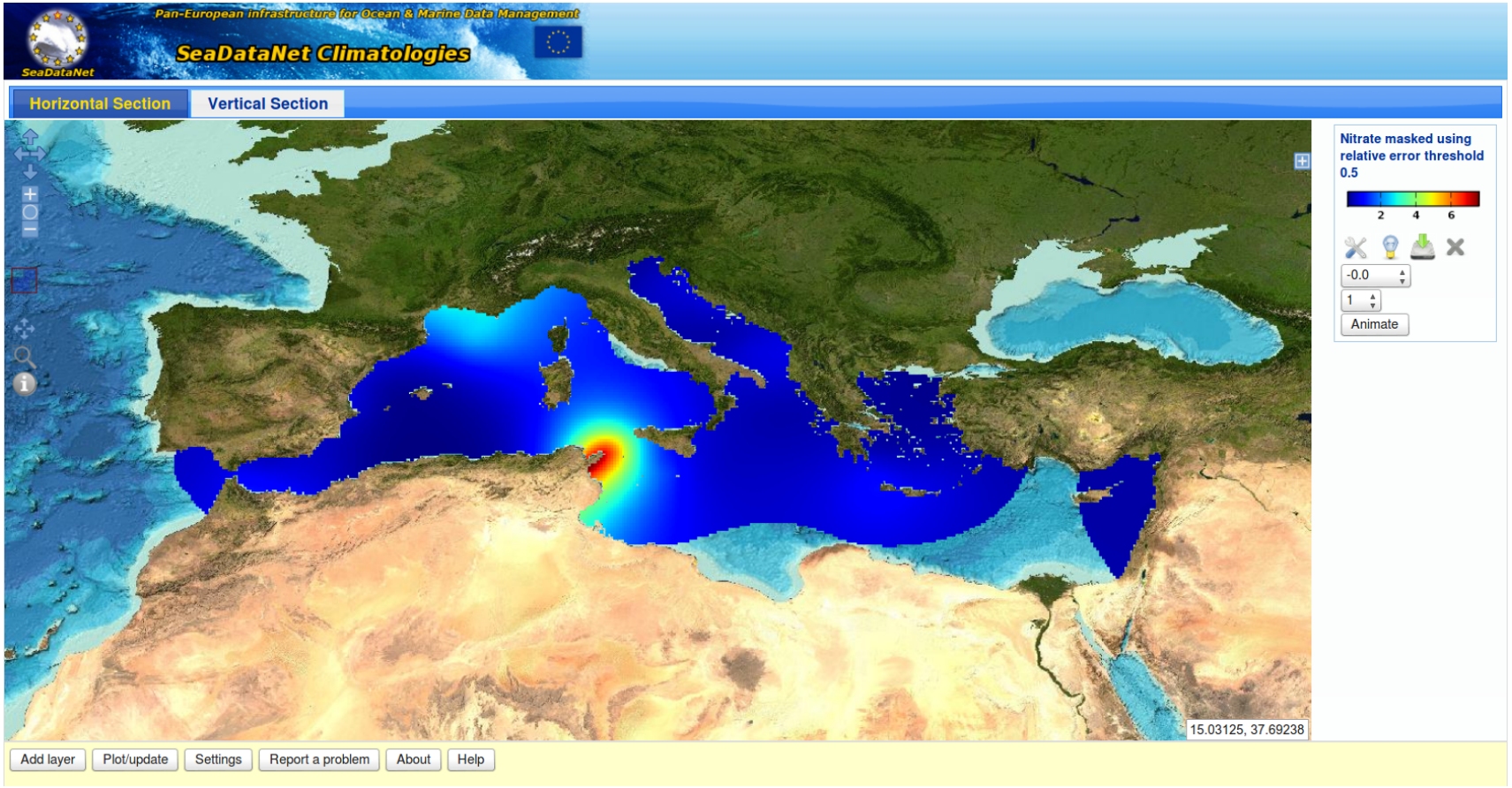
OceanBrowser

Web-based viewer of climatologies (in NetCDF)



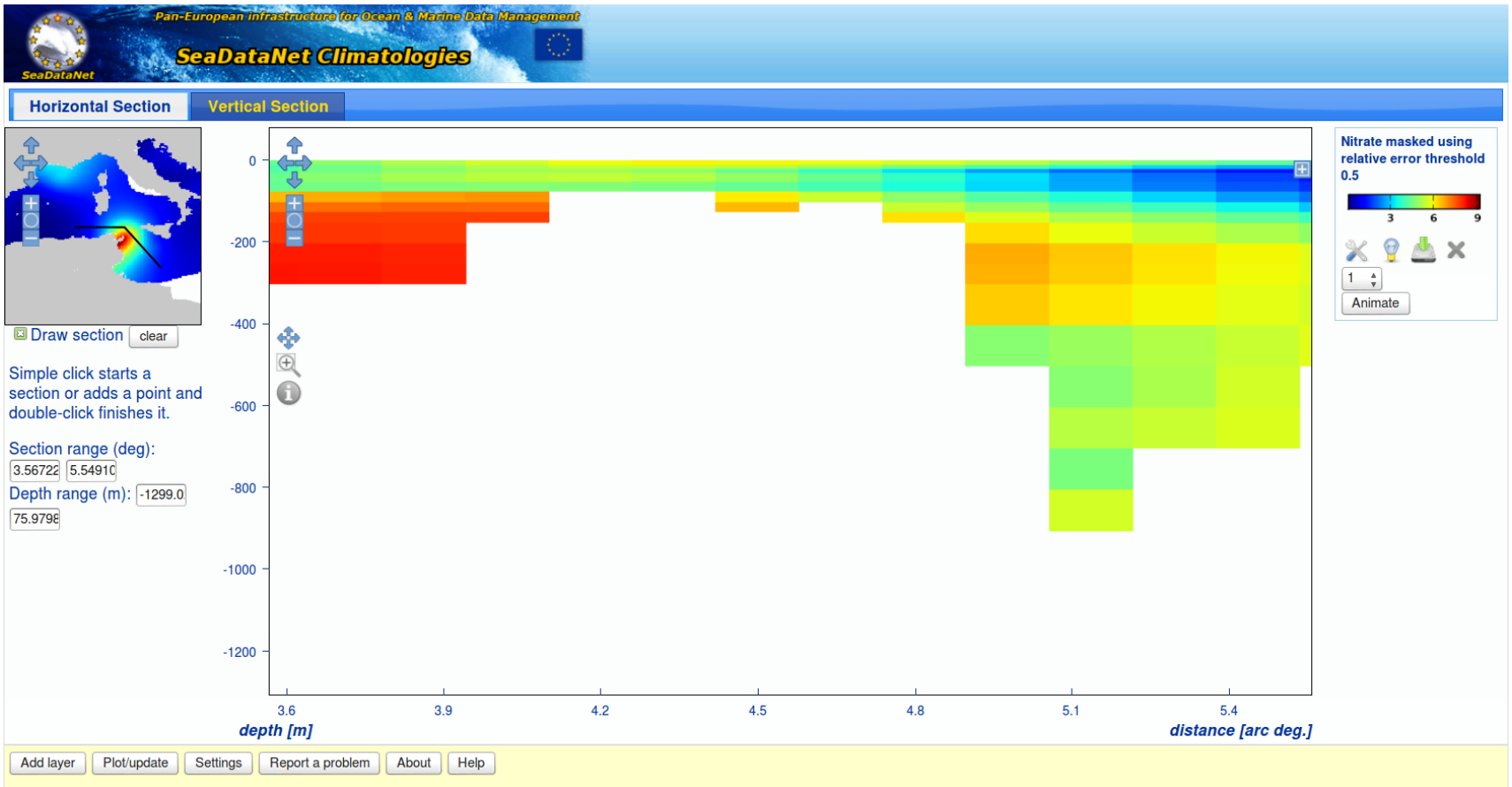
OceanBrowser

Based on OGC standards: WMS, WFS



OceanBrowser

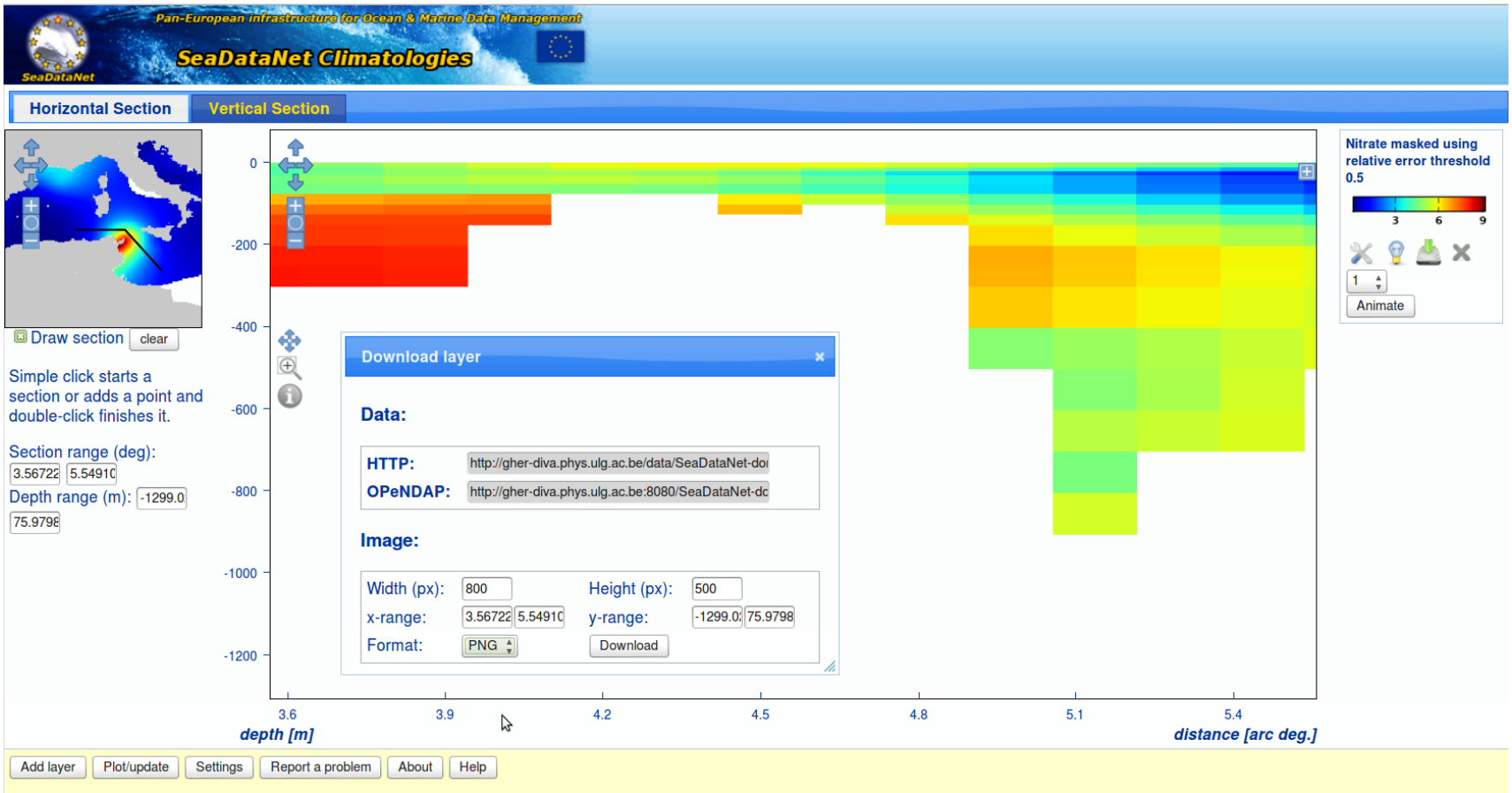
Horizontal section at predefined depth
and arbitrary vertical sections



OceanBrowser

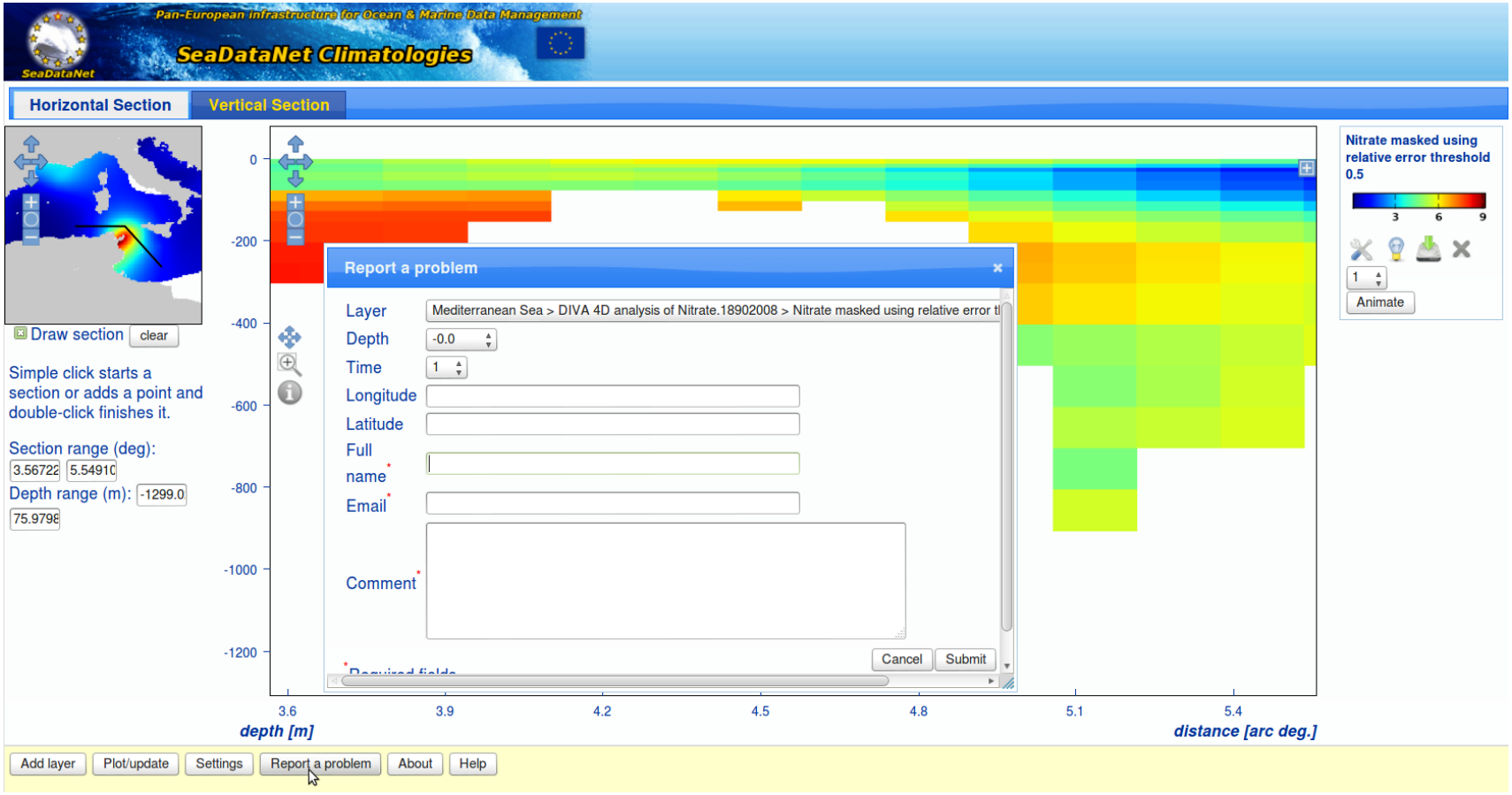
Output formats:

- Images: PNG, SVG, EPS, KML
- Aminations: MP4 and WebM



OceanBrowser

Direct user feed-back ✉



Conclusions

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1. Implementation of Diva in more than 2 dimensions (on a curvilinear grid).
2. The benefit of the advection constraint demonstrated in 2 and 3 dimensions.
3. Various ways (with various degrees of complexity) are offered to use or try this method.
4. A web interface has been developed to visualize the output of Diva aiming to simplify the dissemination of data products.

Thanks for your attention

- http://data-assimilation.net/Tools/divand_demo/html/
- http://gher-diva.phys.ulg.ac.be/web-vis/diva.html
- http://modb.oce.ulg.ac.be/mediawiki/index.php/DIVA